United States Department of Agriculture

Forest Service

Intermountain Research Station

Research Note INT-RN-430

December 1996

Big Sagebrush Seed Storage

Bruce L. Welch
Steven F. Briggs
James H. Johansen

Abstract—Big sagebrush (*Artemisia tridentata* Nutt.) seeds were stored in three different environments: cool, constant temperature (refrigerator 10 °C); room temperature (14 to 24 °C); and a nonheated warehouse (–28 to +44 °C). In all three cases, humidity was held constant and equal. Significant drop in seed viability occurred first in the seed stored in the nonheated warehouse, followed by seed stored at room temperatures, and then seed stored at cool temperatures. It appeared from this study and studies by others that humidity control is more important to maintaining seed viability than temperature control. The old adage simply states "store seeds in a cool and dry place"—but first make sure the seeds have been properly dried. Drying sagebrush seed during the cool, wet weather of the harvesting period creates special challenges to the producer.

Keywords: *Artemisia tridentata, Artemisia tridentata* ssp. *vaseyana*, mountain big sagebrush, seed storage

Big sagebrush (*Artemisia tridentata* Nutt.) is an important plant for many wildlife species, providing food for sage grouse (*Centrocercus urophasianus*), pygmy rabbit (*Brachlagus idahoensis*), pronghorn antelope (*Antilocapra americana*), mule deer (*Odocoileus hemionus hemionus*), Rocky Mountain elk (*Cervus elaphus nelsoni*), Rocky Mountain cottontail (*Sylvilagus nuttalli*), black-tailed jackrabbit (*Lepus californicus*), dark-eyed junco (*Junco hyemalis*), horned lark (*Eremophila alpestris*), Uinta ground squirrel (*Citellus armatus*), domestic sheep (*Ovis aries*), and numerous arthropod and fungi species (Green and Flinders 1980; Kufeld and others 1973; Martin and others 1951; Patterson 1952; Shaw and Monson 1990; Smith and Beale 1980; Welch 1993, 1994; Welch and Nelson 1995; Welch, in preparation). Some of these animals, such as sage grouse, are obligatory feeders on big sagebrush; most, such as mule deer, are facultative feeders. All plant aboveground parts (leaves, stems, flower stalks, seeds, and pollen) are eaten by one or more of these animals.

Big sagebrush plants provide a preferred nesting platform for sage thrasher (*Oreoscoptes montanus*), sage sparrow (*Amphispiza belli*), and Brewer's sparrow (*Spizella breweri*) (Braun and others 1976; Medin 1990, 1992).

With gradual acceptance of big sagebrush as a desirable plant, the use of big sagebrush seed in revegetation or restoration projects has increased dramatically over the past 10 years (Welch 1996, unpublished). There is a need for information about producing, harvesting, drying, cleaning, and storing big sagebrush seed (Booth and others, in press; Stevens and others 1981; Welch 1995, 1996).

From a previous study, Welch (1996) found that big sagebrush seeds should not be stored in environments with humidities above 32 percent. In this study, we tested the effects of constant refrigerator temperature, room temperatures, and the large fluctuating temperatures of a nonheated warehouse on seed viability. In all three cases, humidity was held constant and equal.

Materials and Methods

Just before abscission of seeds (dark tan embryos), all inflorescences from 30 different 'Hobble Creek' mountain big sagebrush plants were harvested (November 1986) by handclipper and placed in separate plastic bags (Welch and others 1986). Next, the inflorescences were dried by placing the bags in a heated laboratory at 22 °C for 3 weeks. Bags were left open and the inflorescences were hand stirred twice each day. Main stems of the inflorescences were hand

Bruce L. Welch is a Research Plant Physiologist and Steven F. Briggs is a Biological Technician, Intermountain Research Station, Shrub Sciences Laboratory, Provo, UT. James H. Johansen is a Natural Resource Specialist, Bureau of Land Management, Boise District, Boise, ID.

stripped of seeds, achenes, floral bracts, and broken fine stem and leaves. A 14 x 14 wires per inch mesh screen was used to separate fine stems and intact leaves from seeds, achenes, floral bracts, and broken fine stems and leaves. The resulting material was rubbed on a finely serrated board to further free achenes from florets.

Final seed cleaning was done with a small-lot airlift seed cleaner; the 30 seed lots were cleaned to a purity of 90 to 95 percent (Booth and others, in press; Welch 1995; Welch and Nelson 1995).

Cleaned seed from the various plants were placed in individual paper seed envelopes that were randomly assigned to one of three storage environments: (1) cool constant or nearly constant temperature (refrigerator 10 °C), (2) room temperatures (14 to 24 °C), and (3) the large fluctuating temperatures of a nonheated warehouse (–28 to +44 °C). Ten seed envelopes were assigned to each storage environment. To maintain constant humidities, the seed envelopes of each storage environment were sealed in four plastic bags. Humidity of the three storage environments were measured by a microprocessor-based relative humidity and temperature hygrometer at 20 °C. Humidities were nearly constant at 19.2 ± 0.4 percent.

Seed viability was determined by using the tetrazolium staining test (Grabe 1970) as outlined by Meyer and others (1987), except that the seeds were exposed to the buffered tetrazolium solution for 24 hours. Seed lot viability was determined at the beginning of the study and for every year after for 9 years. Also, seed moisture was determined at the start of the study and measured again at the ninth year. Seed moisture was determined by placing samples of the seed lots into a convection oven at 100 °C until constant weight was reached and the percent of moisture calculated.

Two statistical analysis procedures were performed on the seed viability data. First, one-way analyses of variance were done each year to detect differences among the three environments (cool, room, and warehouse), 10 replications per environment (Hintze 1992). Alpha level was set at 5 percent. For significant *F*, Newman-Keuls multiple range test was used to detect differences among means.

The second statistical analysis used unpaired, upper level *T*-tests to compare the starting seed viability of each environment to each of the 9 years (Hintze 1992).

Table 1—Big sagebrush seed viability under three different storage environments with humidity held constant. Cool storage was in a refrigerator 10 °C (little temperature fluctuation). Room storage was in a heated and air-conditioned room (temperature fluctuation about 10 °C). Warehouse storage was in a nonheated warehouse (temperatures fluctuation about 68 °C). Data are expressed as means and standard deviations of the percent of live seeds.

Year	Cool	Room	Warehouse
1986	96.7 ± 1.5^{a}	96.3 ± 1.2^{a}	96.4 ± 1.6^{a}
1987	$^{n}97.2 \pm 1.4^{a}$	$^{n}95.5 \pm 2.2^{a}$	$^{n}97.8 \pm 1.1^{a}$
1988	$^{n}96.2 \pm 2.0^{a}$	$^{n}96.3 \pm 1.8^{a}$	$87.3 \pm 4.8^{*}$
1989	$^{n}96.3 \pm 1.6^{a}$	$^{n}96.0 \pm 1.9^{a}$	$^{n}95.7 \pm 1.7^{a}$
1990	$^{n}95.7 \pm 2.0^{a}$	$^{n}95.2 \pm 1.8^{a}$	$^{n}93.5 \pm 1.9^{a}$
1991	$^{n}96.5 \pm 1.9^{a}$	$^{n}95.1 \pm 2.3^{a}$	$^{s}91.9 \pm 4.2^{b}$
1992	$^{n}95.2 \pm 2.2^{a}$	$^{n}94.6 \pm 1.9^{a}$	$^{s}89.3 \pm 4.7^{b}$
1993	$^{n}95.5 \pm 2.1^{a}$	$^{s}81.2 \pm 16.3^{b}$	$^{s}71.8 \pm 12.3^{c}$
1994	$^{s}93.8 \pm 2.1^{a}$	$^{s}70.2 \pm 17.2^{b}$	$^{s}51.0 \pm 17.5^{c}$
1995	$^{s}92.1 \pm 3.3^{a}$	$^{s}53.8 \pm 20.2^{b}$	$^{s}25.9 \pm 14.5^{c}$

Means in rows sharing the same superscripts are not significantly different at the 5 percent level.

Means in columns with an ^{n} are not significantly different from the 1986 seed viability ($\alpha = 0.05$). Those with an ^{s} are significantly different.

*an anomaly in the data set, cause unknown.

Results and Discussion

It was not until 1991, or 5 years into the study, that a significant reduction in seed viability was detected in the warehouse (table 1). Still, the 5-year-old seed stored in the warehouse at constant humidity but widely fluctuating temperatures had a seed viability of 91.9 percent. From 1991, warehouse seed declined in seed viability to 25.9 percent in 1996, or in the ninth year of the study. Seed stored at room temperature showed significant reduction in seed viability compared to cool storage in 1993, or 7 years into the study. However, seed viability for 7-year-old seed was 81.2 percent. This decline continued to 53.8 percent in 1995, or 9 years into the study. For seed stored at cool, nearly constant temperature and humidity, significant reduction in seed viability from the start of 1986 did not occur until 1994, or 8 years into the study; still the seed viability was 93.8 percent and 92.1 percent for 1995, the ninth year of the study.

Mean seed moisture at the start of the experiment was 7.4 percent with a standard deviation of ±0.22. After 9 years, the mean seed moisture was 5.4 percent with a standard deviation of ±0.37 or a reduction of about 2 percentage points. Welch (1996), studying the effects of humidity on storing big sagebrush seed, reported significant seed drying in humidities below 32 percent. Apparently, the paper seed envelopes the seed was stored in absorbed water vapor and created a low enough humidity to dry the seed further.

Conclusions

With humidity held constant at 19 percent, the cool environment with less temperature fluctuation held high seed viability (70 percent or higher) longer. Warehouse environment with its widely fluctuating temperatures was the worst, although it held high seed viability for 6 years. Stevens and others (1981) reported maintaining high seed viability in a nonheated warehouse for 3 years.

Three important keys in storing big sagebrush seed at high seed viability are: seed moisture, storage humidity, and temperature. Welch (1996) studying the effects of humidities on storing big sagebrush seed, reported trouble with seed viability when seed moisture exceeded 9 to 10 percent. In this study, starting seed moisture was 7.4 percent. For the commercial suppliers of big sagebrush seed, it is important to recognize the difficulties of drying seed below 10 percent during the cold, wet weather that occurs during harvesting periods. Forced air heaters are probably needed, and drying should be started as soon as possible. Big sagebrush seed can tolerate being heated to 60 °C for 48 hours (Welch 1996), although using lower temperatures is more economically desirable.

Drying big sagebrush seed during the cold, wet weather of the harvesting period creates special challenges to the commercial suppliers who do not have the facilities for humidity or temperature control. Storing properly dried sagebrush seed in plastic bags may be a good alternative. It appears from this study and from Welch (1996) that humidity control is more important for maintaining seed viability than temperature control. The old adage simply states "store seeds in a cool and dry place"—but first make sure the seed has been properly dried.

Acknowledgments

The authors express their appreciations to Dr. Nancy L. Shaw, Dr. Paul H. Tueller, Dr. Raymond W. Brown, and Mr. Daniel E. Woodruff for providing peer reviews for this manuscript.

References

Booth, D. Terrance; Bai, Yuguang; Roos, Eric E. [In press]. Preparing sagebrush seed for market: effects of debearder processing. Journal of Range Management.

Braun, C. E.; Baker, M. F.; Eng, R. L.; Gashwiler, J. S.; Schroeder, M. 1976. Conservation committee report on the associated avifauna. Wilson Bulletin. 88: 165-171.

Grabe, D. L. 1972. Tetrazolium testing handbook for agricultural seeds. Contribution 29, handbook on seed testing. Springfield, IL: Association of Official Seed Analysts. 62 p.

Green, J. S.; Flinders, Jerron T. 1980. Habitat and dietary relationship of the pygmy rabbit. Journal of Range Management. 33: 136-142.

Hintze, Jerry L. 1992. Number cruncher statistical system version 5.039/92. Kaysville, UT: NCSS 329 N 1000 E, Kaysville, UT. 423 p.

Kufeld, Roland C.; Wallmo, O. C.; Feddema, Charles. 1973. Foods of the Rocky Mountain mule deer. Res. Pap. RM-111. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 31 p.

Martin, A. C.; Zim, H. S.; Nelson, A. L. 1951. American wildlife & plants: a guide to wildlife food habits: the use of trees, shrubs, weeds and herbs by birds and mammals of the United States. New York: Dover Publishing, Inc. 261 p.

Medin, Dean E. 1990. Birds of an upper sagebrush-grass zone habitat in east-central Nevada. Res. Pap. INT-433. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 4 p.

Medin, Dean E. 1992. Birds of a great basin sagebrush habitat in east-central Nevada. Res. Pap. INT-452. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 7 p.

Meyer, Susan E.; Kitchen, Stanley; Wilson, G. Richard; Stevens, Richard. 1987. Supporting evidence for the proposed rule: *Artemisia tridentata* big sagebrush. Unpublished report on file at: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 10 p.

Patterson, Robert L. 1952. The sage grouse in Wyoming. Denver: Sage Books, Inc. 341 p.

Shaw, Nancy L.; Monsen, Stephen B. 1990. Use of sagebrush for improvement of wildlife habitat. In: Fisser, Herbert G., ed. Wyoming shrublands aspen, sagebrush and wildlife management: Proceedings 17th Wyoming shrub ecology workshop; 1988 June 21-22; Jackson, WY. Laramie, WY: University of Wyoming, Department of Range Management: 19-35.

Smith, Arthur D.; Beale, Donald M. 1980. Pronghorn antelope in Utah: some research and observations. Publ. 80-13. Salt Lake City, UT: Utah Division of Wildlife Resources. 88 p.

Stevens, Richard; Jorgensen, Kent R.; Davis, James N. 1981. Viability of seed from thirty-two shrub and forb species through fifteen years of warehouse storage. Great Basin Naturalist. 41: 274-277.

Welch, Bruce L. 1993. Grass is not always king. In: Baker, Michael, ed. Proceedings—XVII international grasslands congress; 1993 February 8-21; Palmerston North, New Zealand. New Zealand Grassland Association: 1775-1778.

Welch, Bruce L. 1994. Rangeland shrubs. In: Artzen, Charles J., ed. Encyclopedia of agricultural science. San Diego: Academic Press, Inc: 575-586.

Welch, Bruce L. 1995. Beyond twelve percent purity. In: Roundy, Bruce A.; McArthur, E. Durant; Haley, Jennifer S.; Mann, David K., comps. Proceedings: wildland shrub and arid land restoration symposium; 1993 October 19-21; Las Vegas, NV. Gen. Tech. Rep. INT-GTR-315. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 126-129.

Welch, Bruce L. 1996. Effects of humidity on storing big sagebrush seed. Res. Pap. INT-RP-493. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 5 p.

Welch, Bruce L. 1996. Unpublished data on file at: U.S. Department of Agriculture, Forest Service Intermountain Research Station, Shrub Sciences Laboratory, Provo, UT.

Welch, Bruce L. [In preparation.] Add three more to the list of big sagebrush eaters. Journal of Conservation Biology.

Welch, Bruce L.; McArthur, E. Durant; Nelson, David L.; Pederson Jordan C.; Davis, James L. 1986. 'Hobble Creek'—a superior selection of low-elevation mountain big sagebrush. Res. Pap. INT-370. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 10 p.

Welch, Bruce L.; Nelson, David L. 1995. Black stem rust reduces big sagebrush seed production. Journal of Range Management. 48: 398-401.

INTERMOUNTAIN RESEARCH STATION

The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

The Intermountain Research Station territory includes Montana, Idaho, Utah, Nevada, and western Wyoming. Eighty-five percent of the lands in the Station area, about 231 million acres, are classified as forest or rangeland. They include grasslands, deserts, shrublands, alpine areas, and forests. They provide fiber for forest industries, minerals and fossil fuels for energy and industrial development, water for domestic and industrial consumption, forage for livestock and wildlife, and recreation opportunities for millions of visitors.

Several Station units conduct research in additional western States, or have missions that are national or international in scope.

Station laboratories are located in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Ogden, Utah

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)